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Antti KUURNE et al.

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For: ANTENNA ADJUSTMENT METHOD, SYSTEM AND NETWORK ELEMENT

CLAIM FOR PRIORITY UNDER 35 USC § 119

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

January 27, 2004

Sir:

The benefit of the filing dates of the following prior foreign application filed in the following foreign country is hereby requested for the above-identified patent application and the priority provided in 35 U.S.C. §119 is hereby claimed:

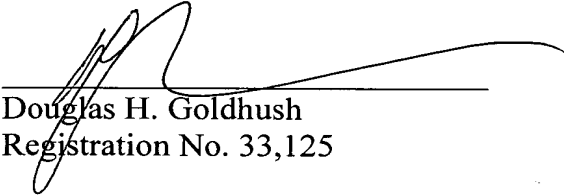
Finnish Patent Application No. 20030964 filed on June 27, 2003 in Finland

In support of this claim, certified copy of said original foreign application is filed herewith.

It is requested that the file of this application be marked to indicate that the requirements of 35 U.S.C. §119 have been fulfilled and that the Patent and Trademark Office kindly acknowledge receipt of this document.

Please charge any fee deficiency or credit any overpayment with respect to this paper
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Enclosure: Priority Document (1)

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PRIORITY DOCUMENT



Hakija
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Patenttihakemus nro
Patent application no

20030964

Tekemispäivä
Filing date

27.06.2003

Kansainvälinen luokka
International class

H01Q

Keksinnön nimitys
Title of invention

"Antenna adjustment method, system and network element"
(Antennisovitusmenetelmä, järjestelmä ja verkkoelementti)

Täten todistetaan, että oheiset asiakirjat ovat tarkkoja jäljennöksiä Patentti- ja rekisterihallitukselle alkuaan annetuista selityksestä, patenttivaatimuksista, tiivistelmästä ja piirustuksista.

This is to certify that the annexed documents are true copies of the description, claims, abstract and drawings originally filed with the Finnish Patent Office.


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Maksu perustuu kaupp- ja teollisuusministeriön antamaan asetukseen 1027/2001 Patentti- ja rekisterihallituksen maksullisista suoritteista muutoksineen.

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Antenna Adjustment Method, System and Network Element

Field

The invention relates to an antenna adjustment method, system and network element of a communication system.

5 Background

In Code Division Multiple Access (CDMA) networks where all the cells share the same frequency, the planning of cell service areas is critical. If the overlap of two CDMA cells is increased, the quality degradation due to interference also increases, as the processing gain does not totally eliminate the influence of the interference. The size of a radio cell can only be affected without hardware changes by changing the transmitted power or antenna configuration (e.g. antenna tilting or antenna bearing). Changing the power potentially requires a base station reset which means clearing the cell of traffic. A base station is also called a node B in UMTS (Universal Mobile Telecommunications System). Additionally, reducing cell power will decrease the received power throughout the cell area, not only on cell edges. Antenna bearing is usually costly to change.

The prior art method for finding out a suitable antenna tilting is based on planning tool predictions on cell service areas. Drive test measurements have been used to complete planning tool results, but this is expensive and time consuming. Each sector has several possible tilt angles for an antenna: the total number of different tilt configurations is A^B (A to power B), where A is the number of different tilt settings per cell and B is the number of cells in the network. For a large city, this number of different tilt configurations might be in the order of 10^{1000} . As can be seen, the problem is that, in practise, it is impossible to try all antenna tilting combinations or even a significant portion of them to find out the best configuration.

Brief description of the invention

An object of the invention is to provide an improved antenna adjustment method, system and a network element of a communication system. According to an aspect of the invention, there is provided an antenna adjustment method, comprising: gathering information on interference in predetermined radio cells, arranging the gathered information radio cell-specifically for processing, determining a tilting factor for each predetermined radio cell which

tilting factor relates to the interference the radio cell produces to other cells, searching for the radio cells having the antenna tilting factors that fulfil a set criteria, tilting the antennas of the searched radio cells.

According to another aspect of the invention, there is provided an antenna adjustment system, comprising: means for gathering information on interference in predetermined radio cells, means for arranging the gathered information radio cell-specifically for processing, means for determining a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells, means for searching for the radio cells having the antenna tilting factors that fulfil a set criteria.

According to another aspect of the invention, there is provided a network element for adjusting antennas comprising: means for gathering information on interference in predetermined radio cells, means for arranging the gathered information radio cell-specifically for processing, means for determining a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells, means for searching for the radio cells having the antenna tilting factors that fulfil a set criteria.

According to another aspect of the invention, there is provided an antenna adjustment system configured to: gather information on interference in predetermined radio cells, arrange the gathered information radio cell-specifically for processing, determine a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells, search for the radio cells having the antenna tilting factors that fulfil a set criteria.

According to another aspect of the invention, there is provided a network element for adjusting antennas configured to: gather information on interference in predetermined radio cells, arrange the gathered information radio cell-specifically for processing, determine a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells, search for the radio cells having the antenna tilting factors that fulfil a set criteria.

Further embodiments of the invention are described in the dependent claims.

The basic principle of one embodiment of the invention is to use pilot-channel signal-strength measurements carried out by a user terminal to give an indication of which cells should be down-tilted. Statistical information

on the measurements is composed, and based on this statistical information it is clarified which cells overlap with many other cells and should therefore be tilted down to reduce the overlap area. Alternatively, soft handover statistics may be used to determine the cells having a large overlap with other cells.

5 The method and system of the invention provide several advantages. An embodiment of the invention saves measurement time and resources. Another advantage is that a actual user distribution is taken into account in determining the antenna tilting.

List of drawings

10 In the following, the invention will be described in greater detail with reference to the preferred embodiments and the accompanying drawings, in which

Figure 1 shows an example of a communication system,

Figure 2 is a flow chart,

15 Figure 3 illustrates the overlapping of two cells,

Figure 4 illustrates an example of a situation where other-to-own cell interference is produced and how the signal strength measurement results may be arranged radio cell-specifically for processing, and

20 Figure 5 shows an example of a radio network controller's logical structure.

Description of embodiments

25 With reference to Figure 1, we examine an example of a data transmission system to which the preferred embodiments of the invention can be applied. The present invention can be applied to various wireless communication systems. One example of such a communication system is UMTS (Universal Mobile Telecommunications System) radio access network. It is a radio access network which includes WCDMA (wideband code division multiple access) technology and can also offer real-time IP-based (Internet Protocol) services which are, for example, IP telephony (IPT), IP-based streaming and IP-multimedia via a connection to an IP network. It is clear to a person skilled in the art that the method according to the invention can be applied to systems that utilize different modulation methods or air interface standards.

30 Figure 1 is a simplified illustration of a digital data transmission system to which the embodiment according to the invention is applicable. This is a part of a cellular radio system, which comprises a base station (or a node B as

it is also called) 100, which has bi-directional radio links 102 and 104 to subscriber terminals 106 and 108. The subscriber terminals may be fixed, vehicle-mounted or portable. The base station includes transmitters, for instance. From transceivers of the base station, there is a connection to an antenna unit, which establishes the bi-directional radio links to the subscriber terminal. The base station is further connected to a radio network controller 110, which transmits the connections of the terminals to the other parts of the network. The base station controller controls in a centralized manner several base stations connected to it.

The cellular radio system can also communicate with other networks such as a public switched telephone network or the Internet.

The embodiments are not, however, restricted to the system given as example, but a person skilled in the art may apply the solution to other radio systems provided with the necessary properties.

Figure 2 is a flow chart showing one embodiment of an antenna adjustment method for decreasing other-to-own cell interference that exists in overlapping areas in cellular communication systems. The embodiment is a method with which it is possible to cut the required time and save resources in finding out the cells where the antennas should be tilted. The aim of the embodiment is, in other words, to get a list of candidate cells to be tilted. The tilting is often down-tilting.

First an example of an overlapping situation is described. Figure 3 illustrates the overlapping of two cells. The system of the example includes a base station 100 generating a radio cell 300, and a base station 304 generating a radio cell 302. The size of the overlapping area 306 can be changed by adjusting antenna tilting. Down-tilting reduces the overlapping area and up-tilting enlarges it. The degradation of quality and/or capacity in a cellular radio network in the case, where the overlapping area of cells is too large, arises from increased interference. The excessive overlap of the cells causes a user terminal to receive pilot signals from too many sectors. This generates other-to-own-cell interference that decreases cell capacity. Additionally, neighbour list planning becomes difficult, since in dense networks more than the maximum number of neighbours can be measured in the area of one cell. This leads to missing neighbours and interference generated from cells outside the neighbour list.

The execution of the embodiment starts in the block 200 in Figure 2.

In block 202, information on interference in predetermined radio cells is gathered. The embodiment utilises prior-art pilot-signal strength-measurements performed by user terminals, handover statistics or other corresponding information. Thus, the data source may be, for instance, periodical pilot-channel signal-strength measurements, event-based pilot-channel signal-strength measurements, soft handover statistics indicating the number of soft handovers from a cell to each neighbouring cell, or the time spent in a soft handover between each determined cell pair (source cell/target cell), potentially combined with the total average power emitted by the base station during a period of time (the period of time might be, for example, relatively long or comprise only busy hours).

In block 204, the gathered information is arranged radio cell-specifically for processing. The data can be arranged, for instance, into a matrix format. One example of the matrix is in Figure 4.

Figure 4 depicts an example of a situation where other-to-own cell interference is produced and how the signal strength measurement results received from a user terminal may be arranged radio cell-specifically for processing. One example of a prior-art pilot-signal measurement carried out by a user terminal is the E_c/I_0 (chip energy per total wideband power) measurement.

The system of the embodiment includes base stations (node B) 100, 304, 402 which generate the overlapping radio cells and a user terminal 106 having radio connections 408, 410 to the base stations 304, 402. The system typically also includes a radio network controller which may be used for storing and processing the measurement information. In this embodiment, the user terminal measures signal strengths of the pilot channels it hears and transmits measurement results to the base station that then forwards them to the radio network controller.

In the matrix 400, the first row corresponds to the cell A, the second row to the cell B and correspondingly, the first column in the matrix corresponds to the cell A and the second column to the cell B. Generally speaking, a row indicates the current serving cell. The serving cell for each measurement report is the strongest of the reported cells in the active set. The active set is a set of radio links simultaneously involved in a specific communication service between a user terminal and a radio access network (RAN) access point. All other cells in the report are measured cells.

In this example, the size of the matrix is 3X3, but the size of the matrix varies according to the number of inspected cells, in other words, according to the number of measured cells.

Let us assume that a measurement report is transmitted by a user terminal 106, which contains three measurement samples from the cells generated by the base stations A 304, B 100 and C 402. The cells are also called here by the names of the base stations. Let the pilot signal of the base station 100 be the strongest, thus the corresponding cell is the serving cell. All samples from the measurement report concerning the base station B 100 contribute to the row B in the matrix. The pilot signal strength measurement report from the cell A (x in the Figure 4 also shown by the dotted line 404) contributes to the E_{cI_0} matrix element whose row is B (i.e. the second row) and column is A (i.e. the first column). Correspondingly, the signal strength sample from the cell C (y in the Figure 4, also shown by the dotted line 406) contributes to the E_{cI_0} matrix element whose row is B and column is C (i.e. the second row and the third column). Finally, the result from the strongest cell B itself contributes to the element B in the E_{cI_0} matrix (not shown in Figure 4). In Figure 4, the user terminal is connected to the cell B.

The way a measurement result relates to a matrix element can vary. The relation may, for example, be a summation to the element's current value, but also a more complex mathematical operation. Typically, each matrix element is formed from several samples gathered from several user terminal measurement reports.

In block 206, a tilting factor, which relates to the interference the radio cell is producing to other cells, is determined. The antenna tilting factor may be determined by calculating an average or a weighted average of the signal strength measurement results measured by user terminals. Other mathematical transformations are also possible. Tilting factor is determined for predetermined cells, which means, for example, that the tilting factor is determined for the cells in a particular geographical area. In principle, the higher the tilting factor, the more probable it is that down-tilting the antenna in that cell will improve the performance of the network. In practice, the embodiment is typically used for finding out candidate cells for tilting. Any further inspections may then be directed to the candidate cells, instead of all predetermined cells.

Next, an example of the determination of a tilting factor is explained. An element of the E_{cI} matrix in a row i and column j e_{ij} can be expressed as

$$e_{i,j} = \begin{cases} \frac{1}{N_{i,j}} \sum_{t=1}^{N_{i,j}} (E_c I_{o_i} - E_c I_{o_j}) & i \neq j \\ \frac{1}{N_{i,j}} \sum_{t=1}^{N_{i,j}} E_c I_{o_i}(t) & i = j \end{cases} \quad (1)$$

where

5 $N_{i,j}$ is the number of measurement reports where cell i is the serving cell and cell j is one of the measured cells,

t means a measurement report,

$E_c I_{o_i}$ means chip energy per total wideband power in a serving cell measured by a user terminal,

10 $E_c I_{o_j}$ means chip energy per total wideband power in a cell j measured by a user terminal,

$E_c I_{o_j}(t)$ is the E_c/I_o value for the cell j in the measurement report t typically expressed as decibels (dB),

Σ is a summing operation.

15

It is possible to calculate the tilting factor according to the equation (1) not taking the parameter $N_{i,j}$ into account, which changes the average of the $E_c I_o$ values to their sum. It is also possible to determine the tilting factor in another way. The reason for proposing the calculation of the average in dB
20 instead of linear units is that the calculation is easier to perform in decibels.

The base stations typically forward the measurement reports they receive from the user terminals to the radio network controller. Therefore, the calculation (and the information arrangement) is preferably performed in the radio network controller. If the total average power emitted by the base stations
25 during a period of time (the period of time might be, for example, relatively long or comprise only busy hours) is taken into account for improving the tilting factor, then the radio network controller delivers the matrix to an OSS (operation and system support) element, for example. In the general case where cells are unevenly loaded, it is beneficial to take the total average power emitted by the
30 base stations into account. The total average power emitted by the base stations during a period of time is taken into the calculation, for example, by using the following equation

$$\tilde{e}_{i,j} = \frac{P_j}{\log_{10}\left(\frac{e_{i,j}}{10}\right)}, \quad (2)$$

where

- 5 $e_{i,j}$ is an element of the $E_c I_o$ matrix in a row i and column j ,
 P_j is the total average power emitted by the base station during a period of time.

The purpose of the equation (2) is to take into account that the $E_c I_o$ values are measured from a pilot channel and therefore do not reflect the total interference produced by the cell to the other cells. Taking the logarithm (log
 10) transfers the result to milliwatts from decibels.

A tilting factor may be calculated for each predetermined cell. This can be carried out by using the equation

$$15 \quad T_i = \sum_j^n \tilde{e}_{i,j}^k, \quad (3)$$

where

- n is the number of rows in the $E_c I_o$ matrix,
 k is a weighting factor,
 20 Σ means summing operation.

The weighting factor k is chosen appropriately to weight the selected tilting factors. Preferably, the weighting factor k determines how much a large tilting factor is weighed in order to make it affect more the total tilting factor calculated by the equation (3). The factor k may vary according to the pre-
 25 vailing circumstances.

In block 208, the radio cells having the antenna tilting factors that fulfil a set criteria are searched for. There are many different options for the criteria the criteria may, for instance, be that the tilting factor exceeds the average of the antenna tilting factors by a predetermined amount (a threshold may
 30 be used).

In block 210, the antennas of the searched radio cells are tilted either up or down. Usually, the tilting is down-tilting to decrease interference.

The exact amount of tilting is found by testing. The adjustment of the tilting may be continuous or gradual.

The execution of the embodiment ends in block 212. The arrow 214 depicts one possibility for repeating the embodiment.

5 Referring to Figure 5, a simplified block diagram illustrates an example of a radio network controller's logical structure. RNC is, as mentioned above, the switching and controlling element of UTRAN. The switching element 500 takes care of the connection between the core network and the user terminal. The radio network controller is located between the Iub 502 and Iu
10 514 interfaces. The network controller is connected to these interfaces via interface units 504, 512. There is also an interface for inter-RNC transmission called Iur 516. The precise implementation of the radio network controller is vendor-dependent.

The functionality of the radio network controller can be classified
15 into two classes: UTRAN radio resource management 508 and control functions 506. An operation and management interface function 510 serves as a medium for information transfer to and from network management functions. The radio resource management function is a group of algorithms used to share and manage the radio path connection so that the quality and capacity
20 of the connection are adequate. Examples of radio resource management algorithms are handover control, power control, admission control, packet scheduling, and code management. The UTRAN control functions take care of functions related to the set-up, maintenance and release of a radio connection between the base stations and the user terminal. In this embodiment, the control
25 functions additionally carry out the determining of the tilting factor, searching for the radio cells to be tilted and, if remote tilting is available, also tilting the selected antennas. In this embodiment, the control function also includes a memory unit 518 for storing the information required in determining the tilting factor in a matrix format, for instance. The memory unit may also be a separate
30 unit.

The functionalities of the embodiment of the invention, such as arranging the information on pilot signal strength measurements and determining a tilting factor, may be carried out by the UTRAN control functions by means of software. The implementation solution can also be an ASIC (Application Specific Integrated Circuit) component, for instance. A hybrid of these different im-
35 plementations is also feasible.

The antenna tilting may be done on site or remotely if the required means are available.

Even though the invention is described above with reference to an example according to the accompanying drawings, it is clear that the invention
5 is not restricted thereto but it can be modified in several ways within the scope of the appended claims.

Claim

1. An antenna adjustment method,
characterized by comprising:

5 (202) gathering information on interference in predetermined radio
cells,

(204) arranging the gathered information radio cell-specifically for
processing,

(206) determining a tilting factor for each predetermined radio cell
which tilting factor relates to the interference the radio cell produces to other
10 cells,

(208) searching for the radio cells having the antenna tilting factors
that fulfil a set criteria,

(210) tilting the antennas of the searched radio cells.

2. The method of claim 1, characterized in that the informa-
15 tion on interference is pilot-channel signal-strength measurement results
measured by user terminals.

3. The method of claim 1, characterized in that the informa-
tion is soft handover statistics.

4. The method of claim 1, characterized in that the informa-
20 tion is the total average power emitted by a base station during a predeter-
mined period of time.

5. The method of claim 1, characterized in that the gathered
information is arranged in a matrix.

6. The method of claim 1, characterized in that the antenna
25 tilting factor is determined by calculating an average or a weighted average of
signal strength measurement results measured by user terminals.

7. The method of claim 1, characterized in that the criteria
is the exceeding of the average of the determined antenna tilting factors by a
predetermined amount.

30 8. An antenna adjustment system, characterized by compris-
ing:

means (106, 108, 100, 110) for gathering information on interfer-
ence in predetermined radio cells,

35 means (110) for arranging the gathered information radio cell-
specifically for processing,

means (110) for determining a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells,

5 means (110) for searching for the radio cells having the antenna tilting factors that fulfil a set criteria.

9. The system of claim 8, characterized in that the information on interference is pilot-channel signal-strength measurement results measured by user terminals.

10 10. The system of claim 8, characterized in that the information is soft handover statistics.

11. The system of claim 8, characterized in that the information includes the total average power emitted by the base station during a predetermined period of time.

15 12. The system of claim 8, characterized in that the system further comprises means (110) for arranging the gathered information in a matrix.

13. The system of claim 8, characterized in that the system further comprises means (110) for determining the antenna tilting factor by calculating an average or a weighted average of signal strength measurement results measured by user terminals.

14. The system of claim 8, characterized in that the criteria is the exceeding of the average of the determined antenna tilting factors by a predetermined amount.

25 15. A network element for adjusting antennas, characterized by comprising:

means (506, 518) for gathering information on interference in predetermined radio cells,

means (506, 518) for arranging the gathered information radio cell-specifically for processing,

30 means (506, 518) for determining a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells,

means (506, 518) for searching for the radio cells having the antenna tilting factors that fulfil a set criteria.

16. The network element of claim 15, characterized in that the information on interference is pilot-channel signal-strength measurement results measured by user terminals.

5 17. The network element of claim 15, characterized in that the information is soft handover statistics.

18. The network element of claim 15, characterized in that the information is the total average power emitted by the base station during a predetermined period of time.

10 19. The network element of claim 15, characterized in that the network element further comprises means (506, 518) for arranging the gathered information in a matrix.

20. The network element of claim 15, characterized in that the network element further comprises means (506, 518) for determining the antenna tilting factor by calculating an average or a weighted average of signal
15 strength measurement results measured by user terminals.

21. The network element of claim 15, characterized in that the criteria is the exceeding of the average of the determined antenna tilting factors.

20 22. The network element of claim 15, characterized in that the criteria is the exceeding of the average of the determined antenna tilting factors by a predetermined amount.

23. An antenna adjustment system configured to:
gather information on interference in predetermined radio cells,
arrange the gathered information radio cell-specifically for process-
25 ing,
determine a tilting factor for each predetermined radio cell, which
tilting factor relates to the interference the radio cell produces to other cells,
search for the radio cells having the antenna tilting factors that fulfil
a set criteria.

30 24. A network element for adjusting antennas configured to:
gather information on interference in predetermined radio cells,
arrange the gathered information radio cell-specifically for process-
ing,

35 d termin a tilting factor for each predet mined radio cell, which
tilting factor relates to the interf rence the radio cell produces to other cells,

search for the radio cells having the antenna tilting factors that fulfil a set criteria.



15

1

(57) Abstract

The invention is related to an antenna adjustment method, system and network element. The system comprises means (106, 108, 100, 110) for gathering information on interference in predetermined radio cells, means (110) for arranging the gathered information radio cell-specifically for processing, means (110) for determining a tilting factor for each predetermined radio cell, which tilting factor relates to the interference the radio cell produces to other cells, means (110) for searching for the radio cells having the antenna tilting factors that fulfil a set criteria.

(Figure 5)



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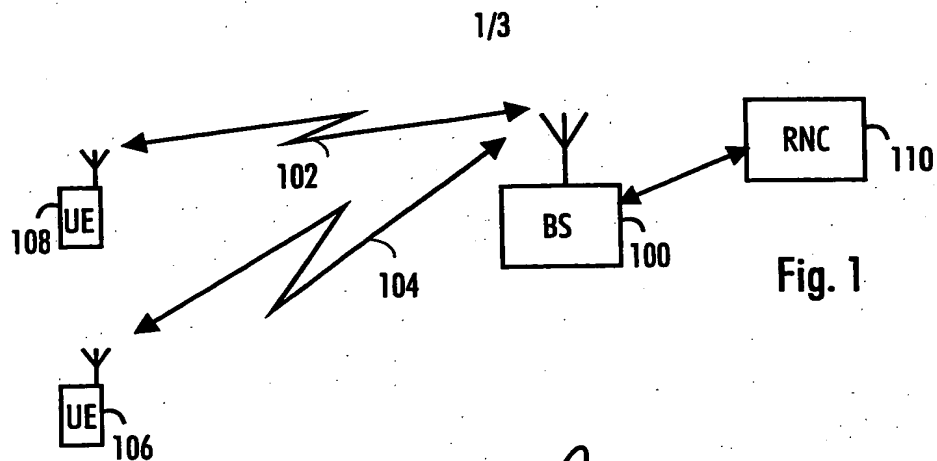


Fig. 1

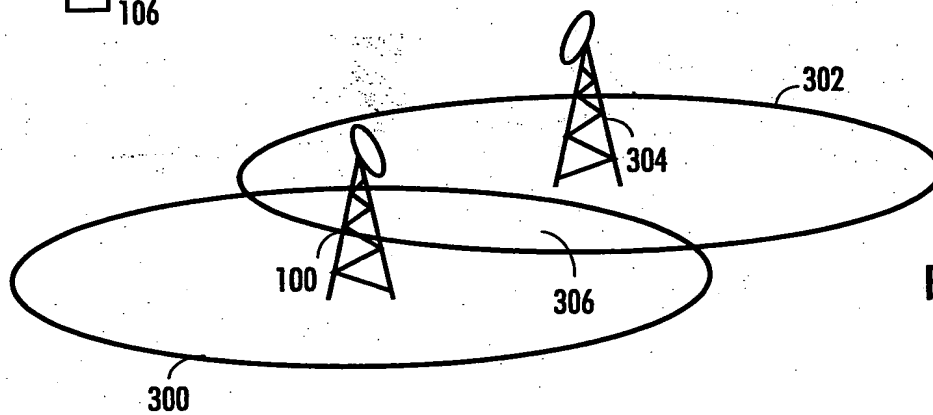


Fig. 3

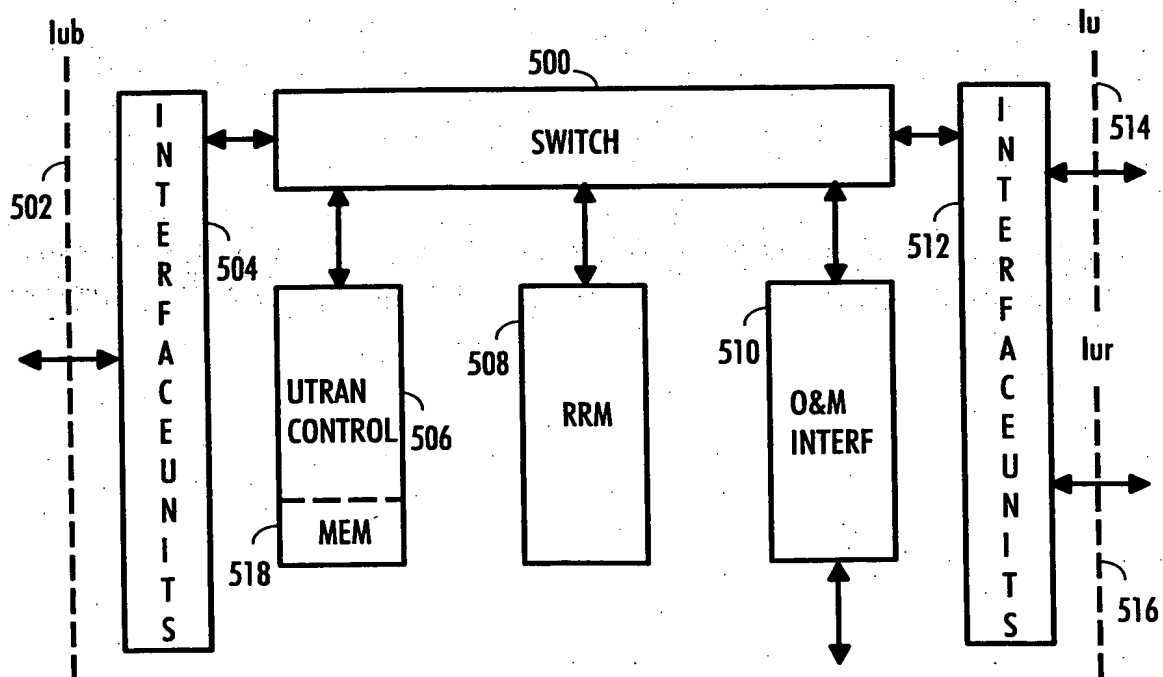


Fig. 5

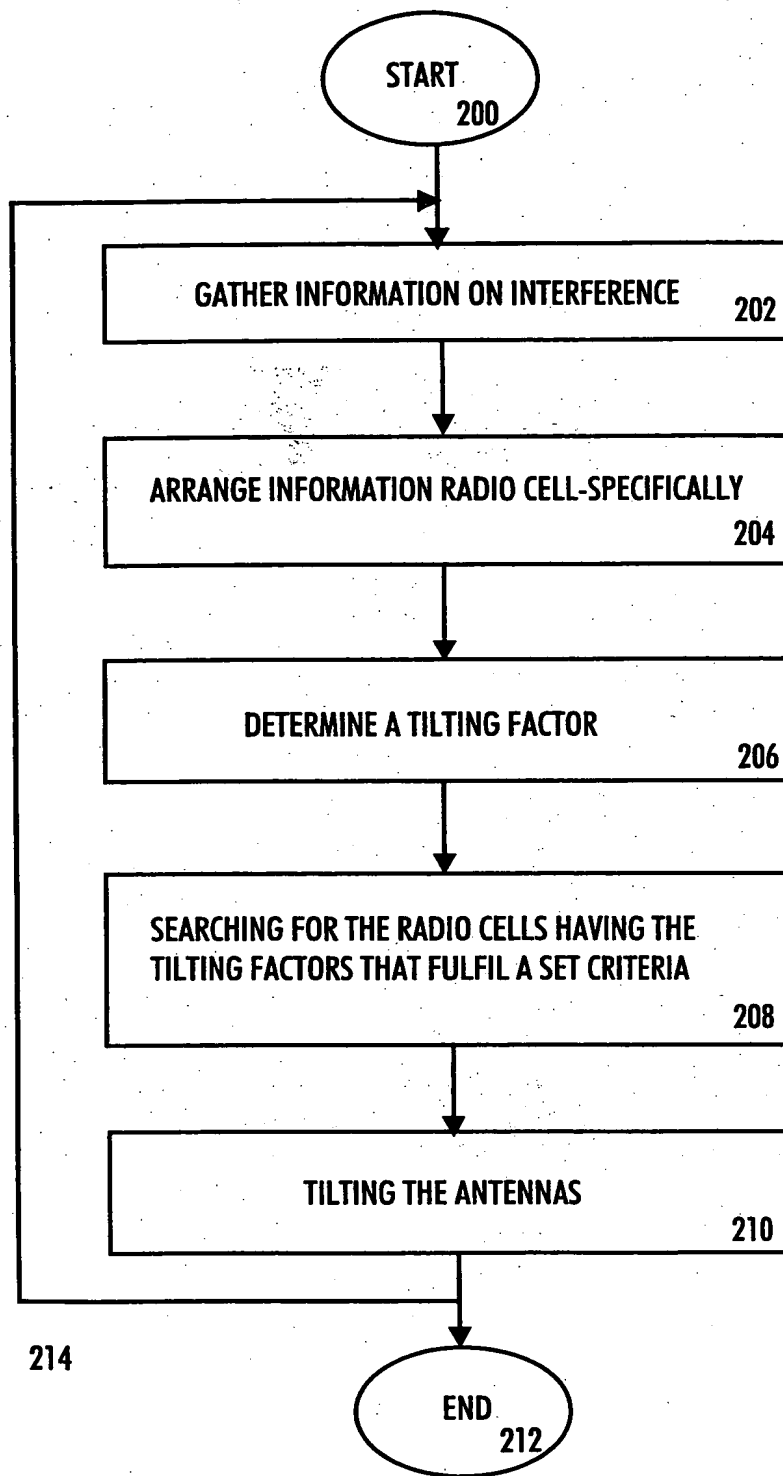


FIG. 2

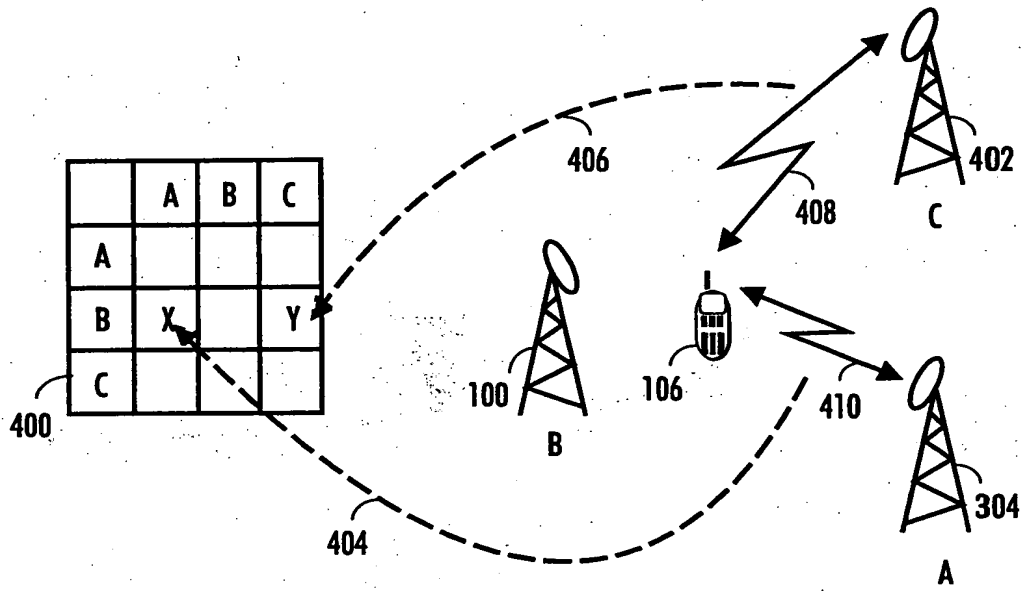


Fig. 4